Gulf Research Reports, Vol. 6, No. 3, 249–260, 1979.

STUDIES OF THE SOUTHERN OYSTER BORER, *THAIS HAEMASTOMA*

GORDON GUNTER
Gulf Coast Research Laboratory,
Ocean Springs, Mississippi 39564

ABSTRACT Original work was carried on at the U.S. Bureau of Fisheries Laboratory on Apalachicola Bay from August 1935 to April 1936. Since then observations have been made in Texas, Louisiana and Mississippi. Five papers on specific aspects of the biology of the animal have been written since on this and other predatory gastropods. Here all commentaries are drawn together and unpublished matter is presented.

The name *Thais haemastoma* is used because separations based upon the rugosity of the shells do not hold up. Perfectly smooth and very rugose specimens are found in the same bays, with various shell characteristics being related to various oyster reefs on which they grow.

Radular movement is by the band-over-pulley method suggested by Husley (1853), Herrick (1906) Gunter (1936) and Carriker (1943). Evidence is presented showing that *Thais* can kill oysters without mechanical injury, presumbly by some paralytic material. About one-third of the oysters are opened by large *Thais* without any boring whatsoever. Smaller *Thais* are more prone to bore complete holes into the shell cavity of the prey. In Apalachicola Bay large *Thais* may eat one oyster about every 8 days and it was calculated that on St. Vincent's Bar 24 million adult oysters could be killed in a year.

The resting gonads consist of a thin layer of tissue on the body over the liver and they are lavender-grey in the males and yellowish-orange in the females. They begin to thicken in January and the color intensifies. Egg laying takes place from April to July on the Gulf coast. No young or small *Thais* were seen in Apalachicola Bay probably because of heavy fresh-water drainage in the springs of 1934 and 1935. Several hundred *Thais* were measured and each month the length frequency mode was at 80.0 mm. The largest known specimen of *Thais*, a Louisiana specimen, was 103 mm long.

A heavy kill of *Thais* took place in the spring of 1935 and no adults survived in Apalachicola Bay except on Hiles' Bar near Indian Pass, which is close to the ocean. The *Thais* seemed to perish when salinity dropped to 9‰ and stayed that way for several weeks. Both oysters and mussels survived at salinities lower than *Thais* could withstand.

Thais shells are extremely hard and are difficult to break with a hammer. Nevertheless, they are cracked by stone crabs. They are also invaded by commensals such as the boring clam *Diplothyra smithii*, the annelid worm *Polydora websteri*, and the boring sponge *Cliona*.

In Louisiana a so-called conch line was established by St. Amant (1938) when it was found that adult conchs did not get much beyond the area in Barataria Bay where the salinity fell to around 20‰. This was confirmed later by J. G. Mackin and Gunter at about 18‰, but has not been published. It has also been found that baby conchs are found landward of this line. It was found by experiments that conchs were generally killed by water registering 9‰ salinity and, additionally, that snails taken from low-salinity water survived transfer to still lower salinities or lived longer even in lethally low salinities than those coming from higher salinities.

Attempts to trap conchs on oyster beds were unsuccessful because no baits more attractive than the surrounding oysters and mussels could be found. The conchs' activity stopped at temperatures of 10°C and below.

PROLOGUE

Generally the human equation is not mentioned in scientific papers, although authors sometimes speak sharply about the data or presentation of other writers in the same field. However, it will clarify things to explain why the work described herein was begun 45 years ago and is slow in coming to an end. In barest terms, it was started under Dr. Paul S. Galtsoff in Washington and his resident assistant at the Indian Pass Laboratory, who was not noted for productivity. Furthermore, neither Dr. Galtsoff nor the writer was widely known for amiability and forbearance in those days. The upshot was that in less than eight months I turned in a report and left the employ of the U.S. Bureau of Fisheries permanently in 1936. Publication as a bureau paper was not approved. I kept the manuscript with the hope of adding to it, and have gained more information about *Thais* since that time. This has been used in commentary and the paper has been extended.

Manuscript received July 2, 1979; accepted July 20, 1979.

INTRODUCTION

Work was carried on from August 22, 1935, to April 15, 1936, at the Indian Pass Laboratory of the U.S. Bureau of Fisheries on Apalachicola Bay, Florida. It was planned as an integral part of the oyster pest investigation of the U.S. Bureau of Fisheries which extended from Massachusetts to Texas and ran from June 1935 to July 1936.

The objectives of these studies were to determine to what extent *Thais* is a pest; to study its distribution and life history; and to devise a means of control, if possible.

The work consisted of field studies in Apalachicola and nearby bays, but principally the former, and experiments and observations conducted in the laboratory. In the years after 1936, further observations were made in Texas, Louisiana and Mississippi.

THE ANIMAL STUDIED

This snail is a prosobranchiate gastropod belonging to the order Stenoglossa. It was formerly considered to belong to the family Muricidae by taxonomists, but others separated the Purpuridae or Thaisidae from the larger group (cf. Clench 1947).

The species has been variously listed in the older literature as *Purpura haemastoma*, *P. floridana* and *P. h. floridana*. Johnson (1934) lists it as *Thais floridana floridana* Conrad. Clench (1947) considers that the United States specimens may be divided into two subspecies, *Thais haemastoma floridana* Conrad, which ranges from North Carolina around Florida to Pensacola and through the Indies to Venezuela, and *T. h. haysae* Clench, a large nodulose form living from western Florida to Texas. These subspecies are supposed to be separable generally on the basis of shell nodules (smooth to very rugged), and size. However, St. Amant (1938) found conchs in Barataria Bay which he could separate into these categories and Butler (1954) found both types in Pensacola Bay. He says that these differences will probably ultimately be shown to be environmental. Our own experience has been that there is no rhyme or reason to the distributions of these two supposedly different conchs along the Gulf coast. Conchs are variable on different reefs in the same bay and may be recognized as to reefs of origin, just as oysters are. In Apalachicola Bay in 1935, there were populations on some reefs which were no more rugose or nodulated than a *Polinices* shell, although they were not slick, while nodulated populations existed on other reefs in the same bay.

In commenting upon these differences, in an unpublished report submitted to the Bureau of Fisheries in 1936, the author said that they indicated one of two things: either the groups from different localities do not mix with other strains or, if they do mix due to relatively wide distribution of pelagic larvae, differences in local environments cause them to grow in different ways. The latter supposition is much more likely. Cook (1895) presented data showing differences between shells of a gastropod associated with locality difference.

The writer has gathered the impression that the amount of nodules present depends somewhat upon the size of the animal. There is a tendency for the *Thais* in the "Louisiana Marsh" region, east of the Mississippi River, to be larger and more rugose than those elsewhere; this is also a region where large oysters abound and today it is probably the largest natural oyster-producing ground on Earth.

Therefore, there seems to be no reason for assigning two subspecific names to the *Thais haemastoma* complex in the Gulf. Conrad's *floridana* is only given subspecific rank by leading American conchologists and according to Clench (1947) it is "exceedingly close to the typical form" (*haemastoma* of the Mediterranean, Africa, east and west coasts of South America, west coasts of Middle America and Mexico) from which it is said to be separable by color and being less nodulose. But since some of the northern Gulf *Thais* are as nodulose as any *haemastoma* there seems to be no good reason to adopt *floridana* either as a specific or subspecific name for this group. Very extensive statistical analyses, probably of larger collections than are now available anywhere, must be made before the situation becomes clear. Indeed this may not suffice and other procedures such as serological, chromosome analyses, soft anatomy and life history studies may also be necessary. Such an undertaking may not be considered worthwhile for a long time to come, if ever. In the meantime it would seem the remaining conservative course is to use the only indubitably valid name, *Thais haemastoma*.

External Anatomy

The shell is a dextral, spirally coiled valve. There are seven whorls, the last and largest being known as the body whorl. Beginning near the apex and progressing spirally on the whorls is a double row of tubercles, leading to the aperture, which increase in size as they progress until they become blunt cones or nodules. They are much more pronounced in some animals than others and in some from other localities they are completely absent. The columella is straight and without a lumen. The aperture is prolonged as a short, open siphonal canal.

Like all members of the Stenoglossa, *Thais* has a long retractile proboscis containing the odontophoral apparatus and having the mouth opening at its extremity. The odontophoral mechanism of the *Thais* is doubtless similar to that of other prosobranchs, but it has not been described in print. Gunter (1936) analyzed radular movement of *Thais* and several other prosobranchs as a drilling mechanism.

Several members of the genus *Thais* are known as rock shells, presumably because they are often found on rocks. However, the name is also appropriate because the shells are so hard. They are quite difficult to break with a hammer even on a rock surface, and they are opened easily only by cracking them in a vise. Nevertheless, Butler (1954) says they are cracked and eaten by hungry stone crabs (*Menippe mercenaria*). The writer has observed the same thing and Powell and Gunter (1968) showed that *Menippe* would kill and eat *Thais* in laboratory aquaria.

In spite of their hardness, *Thais* shells are sometimes invaded by three kinds of shell-perforating organisms. These are the boring sponge *Cliona*, the boring clam *Diplothyra smithii* (*Martesia* of most authors), and polychaete worms, *Polydora* sp. There are also little patches of closely adherent, green alga on many *Thais* and quite often, one or more fairly large oysters of either *Crassostrea virginica* or *Ostrea equestris*, species found on the Gulf coast.

The siphon is a prolonged, roughly rectangular flap of the pallium leading out from the gill chamber, and is normally folded together by the animal to form a tube. The mantle or gill chamber contains the gill and the ctenidium near the siphon. On the right side is the anus and rectal gland. This gland gives off a yellow mucous the function of which is unknown; it turns purple in sunlight. Before the days of the Greeks and Romans, the Minoans of ancient Crete used Mediterranean mollusks of the genus *Thais* and the related genera *Murex* or *Purpura*, to make the famous dye later known at Tyrian purple, which comes primarily from the rectal gland.

When extended, the pedal base of the snail is a broad, rectangular organ with the operculum on the posterior dorsal surface. The operculum completely closes the aperture when the foot is drawn in. It is made of thin, horny material. The nucleus of the operculum is lateral.

The two eyes are sessile on the outer side of the base of the nonretractile tentacles. They have not been studied histologically and their grade of complexity is unknown. The eyes of *Thais* are not very well developed and apparently they are of use only in distinguishing light from darkness or degrees of darkness.

The head consists, externally, mostly of a slightly raised portion bearing the tentacles. This part is not often exposed even when the animal is crawling about on solid surfaces. The tips of the tentacles, for about 3 or 4 mm, are smaller in diameter than the rest, and are retractile within the tentacles. They are black except at the very end and are probably light sensitive.

The pedal base is a light cream color and the upper surface of the flesh is a light, finely streaked brownish-grey. The shells are various shades of yellowish-brown.

The gonads are a thin sheet of tissue lying over the liver on the body coil. In the females they are of a pale yellow color tinted with orange, while in the males they are of a color best described as lavender-grey. These colors change as the breeding season approaches and become more vivid.

All animals, except a very few females, have an S-shaped penis attached slightly behind and to the right of the right tentacle. This organ was observed to be large in the males, while in the females it ranges from an almost indiscernable rudiment to a size nearly as large as that of the males in some individuals.

No sexual dimorphism could be discerned by general observation and several measurements made on the shell.

Large *Thais* approach 100 mm in length in Florida and Louisiana waters. The largest specimen on record seems to be one 103 mm long from Grand Bayou, Louisiana (Clench 1947). A group of 53 "large" conchs brought in from the oyster reefs of Mississippi Sound in February 1956 ranged from 72 to 96 mm in length and averaged 82.5 mm. After being dried in room air for 2 days, the weight of these animals ranged from 58 to 124 g, averaging 80.0 g.

PREVIOUS WORK

Ritter (1896), Kibbe (1898) and Swift (1898) mentioned among their lists of oyster enemies on the Gulf coast, a snail which they called variously, drill, conch, whelk or borer. The specific name was not given by these Navy officers but it appears that their references were to *Thais*.

Moore (1899, p. 91) says that *Purpura* "causes considerable damage" on oyster beds in Louisiana. He placed several with oysters in aquaria but stated that they did not "molest them in any way." He says that *Thais* (*Purpura*) "is found everywhere on the oyster beds of Louisiana excepting the less saline waters," and that the fishermen held it responsible for the destruction of the oysters of Chandeleur Sound.

Moore (1907) later reported that *Thais* was not destructive on the oyster bottoms of Texas. This was an error. *Thais* causes as much damage in Texas as it does elsewhere.

Moore and Pope (1910) tried experiments by placing boxes of oysters and *Thais* together and boxes of oysters alone on oyster beds for over 2 months. When these were taken up it was found that only 2% of the spat survived and all upper valves of the dead spat which remained showed small round perforations, which were attributed to *Thais*. These workers also state that only spat were attacked and it is safe to say that adult oysters are not damaged due to their thicker shell.

Moore and Danglade (1915, p. 41) stated that they found "practically no oysters" killed by *Thais* in Lavaca Bay and that they, being essentially saltwater animals, are confined to the lower part of the bay.

Churchill (1920) gave a brief summary of information on *Thais* up to that time.

The paper of Burkenroad (1931) seems to be the only one in the literature up to then concerning this animal alone. His chief findings were that: (1) Both sizes of oysters are eaten, but the smaller ones are preferred. (2) Mussels (*Mytilus*) are preferred to oysters. (3) *Thais* seems to be unable to live in water of low salinities and its range therefore does not completely coincide with that of the mussel or the oyster. (4) During the breeding season *Thais* displays a strong negative geotropism so that it can be trapped at that time by driving stakes on the beds and taking them up after the animal has climbed them.

St. Amant's (1938) master's thesis said that adult conchs lived in water with a salinity of 20°/₀₀ or higher. This was called the conch line. J. G. Mackin and the writer have found this line to be at about 18.0°/₀₀ and that small *Thais* live beyond the line in water of lower salinity. St. Amant found that the snails became inactive when the temperature fell to 10°C. He found them scarce on mud bottoms. Oysters were said to be the chief food. Development of the early stages was mentioned and the incubation period within the egg capsules was said to be 10 to 12 days, after which the larvae hatched. The breeding season was recorded as early March to late July with a peak in April and May.

BEHAVIOR OF *THAIS* IN THE LABORATORY

The writer has made many observations of *Thais* in the laboratory in Florida, Texas, and Mississippi over many years. The general conclusions are drawn together in the following account. I am indebted to Ms. Judy Williams and Miss Kay McGraw for help in the laboratory and to many zoologists for long discussions, chiefly D. W. Menzel, Lyle St. Amant, J. G. Mackin, A. S. Pearse, Frank W. Weymouth, William J. Demoran and Sewell Hopkins.

When first brought into the laboratory the animals are closed, sometimes completely, but usually with the siphon extending from under the operculum into the siphonal canal. When placed in tanks or jars with running sea water they usually opened and attached themselves by the foot to the substrate in less than 30 minutes. Those that did not open were dead or moribund. In cool weather animals lived in air over a week, if not exposed to the sun. In warm weather they died in 2 or 3 days under the same conditions.

When placed in the air *Thais* would attach to the substrate but could move very little if it was dry. They seemed to live and move about indefinitely on water tables in which the foot was submerged in only a millimeter or so of running sea water.

Action of the Foot

The foot of *Thais* progresses by small waves which start at the rear and move forward. There is an unseen division mark along the center of the foot and thus there are separate waves for each side. These start alternately and there are two waves on either side at one time. They do not extend at right angles across the foot, but are diagonal with the inner ends ahead of the lateral ends. Foot waves of gastropods are of various types and a classification of them was introduced by F. Vles, the French zoologist, in the early 1900s. According to this classification the foot waves of *Thais* are of the direct, ditaxic, alternate, diagonal type, which is virtually self-explanatory. It has been observed that the anterior margin of the foot is made up of a distinct band of tissue which undergoes a forward rippling motion not connected with the pedal waves.

Thais can twist or turn the pedal base in any direction, but none was seen to crawl backwards.

By shooting a strong stream of water under the foot, the writer has shown that the animals can cling to the sides of a glass jar with less than one fifth of the total area of the foot attached. The powers of suction and attraction to the substrate are local. This ability and the fact that *Thais* can turn and twist in any direction enables it to crawl about over oyster bars with ease.

When feeding, *Thais* folds the front part of the foot so that it forms a short enclosed tube at its anterior portion through which the proboscis is extended. Animals in the natural state were not observed to feed with the proboscis unprotected or extended so that it could be seen, although it is possible they do, for they could be induced to do so as described below.

Thais haemastoma seems to be much more sensitive with regard to its proboscis, mouth and drilling apparatus than *Melangena corona* (Gunter and Menzel 1957). The latter gastropod seems to attack its victims when they are lively and far from dead, and lies about feeding with the whole proboscis extended and exposed. In contrast, *Thais* is secretive and protective and in natural life seems never to have its proboscis exposed, but either retracted or covered by the foot.

Demoran and Gunter (1956) thought to remove the proboscis of *Thais* and see how they would handle oysters then. To our considerable surprise this whole complicated apparatus was regenerated in 3 weeks time and the conchs went about cutting the edge of the oysters' shells and killing them just as before.

The pedal groove runs transversely across the anterior margin of the foot. In *Buccinum* and *Murex* this is the opening for glands which secrete the egg capsules (see Fretter 1941); the same is true for *Purpura* as shown by Pelseener (Dakin 1912). Egg laying in *Thais* was not observed.

The foot of *Thais* apparently contains taste buds, as was shown for *Busycon* and *Ilyanassa* by Copeland (1918).

In short, the foot functions in five known ways, namely, in locomotion, as an organ of taste, in protection of the proboscis, and probably in formation of egg capsules. It also seems to act as an accessory boring organ as shown below.

Use of the Sense Organs

Copeland (1918) has shown that in *Busycon* and *Ilyanassa* the osphradium is the organ of smell. This seems to be true of *Thais* also. When the animal is crawling about the siphon is continually moved from side to side or up and down so that it seems to be testing the water. In all probability water drawn into the siphon is "smelled" in the gill chamber by the osphradium.

Copeland (1918) has described the reactions of *Busycon* and *Ilyanassa* to food. There is a regular sequence of events which the writer has observed to be essentially the same in *Fasciolaria gigantea, Busycon perversum, Melongena corona* and *Thais haemastoma.* Although Copeland has made no such claims, these observations lead this writer to believe that the responses to food described by Copeland for the two above species are common to most carnivorous gastropods.

These reactions may be described as follows:

If a drop of oyster juice is placed on the tip of the siphon it contracts quickly and sharply. The animal then comes farther out of the shell and waves the siphon from side to side. If no further stimulus is given the animal begins to crawl about, waving the siphon meanwhile. If the stimulus came from one side the snail moves to that side.

If the foot, head or tentacles are touched with a piece of oyster meat or a drop of juice, they recoil in the same manner and then the animal begins to move about. If the meat is left in contact with the foot and held so that the animal can feel it, but not fold the foot around it, the proboscis is slowly projected until it touches the meat and begins to rasp. If the meat is slowly moved down the side

Bay were sieved through three meshes of wire. The first was ordinary poultry wire, the second was galvanized wire mesh and the third was ordinary screen wire. This work was carried on from December 1935 to March 1936. No small *Thais* except the five listed above were found, although hundreds of small gastropods were caught, some of them being as small as 2 mm in length.

The fact that all the young caught were taken on the bars seems to indicate that this is their natural habitat. Isolated specimens of large *Thais* have been reported from 13, 15 and 50 miles in the open Gulf. There is no explanation of their scarcity, unless it is that the 1935 breeding season was unsuccessful. Reliable men who have worked on the bay for years said that in some years reproduction does not take place and that the 1935 season was one of comparative scarcity of eggs.

The gonads of both males and females began to thicken and enlarge in January. Previous to that time the gonads had been only thin strips of tissue over the liver coil. By the end of March 1936, the gonads were about 2 mm thick and had changed color in both sexes. Those of the female were light cream color and those of the males were of a waxy yellowish-orange color.

Dr. A. S. Pearse (personal communication) observed the animals breeding in June of 1935. The last day he observed animals laying eggs was on June 19. He observed the animals congregated in bunches so that in some localities on St. Vincent's Bar a half bushel of *Thais* were tonged in one bushel of total tonged material.

SALINITY EXPERIMENTS

Four sets of salinity experiments were carried out.

In experiment 1, six sets of glass dishes were used containing two *Thais* and 1 liter of stagnant water. The experiments were started on November 19, 1935. The salinities of water in sets of dishes 1 to 6, respectively, were: distilled, 5.80, 10.93, 20.45, 30.59 and 34.19°/₀₀. The last was the same as the running sea water of the laboratory from which the animals were removed.

Animals in sets 5 and 6 attached in 20 minutes. Those in set 4 opened in an average of 5 hours. No animals in the first three sets (salinities: distilled, 5.80 and 10.93) attached at all. On November 24, one animal from each jar of sets 1 to 3 were placed in running sea water of the laboratory which was approximately at a salinity of 30.99°/₀₀. These all revived in 6 hours. On the tenth day one animal from each of the same sets were placed in running sea water at a salinity of approximately 25.00°/₀₀. The animal from set 3 (salinity 10.93) revived, while the other two did not. On the thirteenth day all of the single remaining animals in set 3 were dead.

On the tenth day one animal in set 5 died from unknown causes. All other animals in sets 4 to 6 remained attached and sensitive to touch throughout the experiment and were discarded on November 28.

The temperatures and pH of the water in each jar were taken 18 times during the experiment. At the beginning of the experiment the pH of sets 1 to 6 was: 6.8, 7.3, 7.4, 7.7, 7.8 and 7.9, respectively. As time passed, the pH in the lower sets rose and that of the higher sets fell and on November 28, ranged between 7.4 and 8.0, averaging 7.6 for all jars.

Unfortunately temperatures could not be controlled. At the beginning of the experiments they ranged from 16.8 to 17.0°C and later rose to as high as 22.4°C; then fell to 9.2 and rose again to 19.4. Nevertheless, they were comparable from jar to jar and did not differ more than 0.8°C at any one time.

Animals in a moribund condition were tested for sensitivity by pricking the siphon. If there was no reaction they were placed in sea water, where they sometimes revived. The best criterion of death was the strong putrid smell, apparently emanating from the rectal gland, which set in soon after death. No animal giving this smell ever revived in sea water although they seemed otherwise to be in the same condition as some animals which did revive.

This experiment shows that *Thais* removed from water of comparatively high salinity (35.00°/₀₀) can be placed suddenly in water as low as 20.45 and after accustoming themselves, live in it. Also *Thais* removed from the same water and placed in water lower than salinity of 10.93°/₀₀ cannot accustom themselves as shown by the fact they remain closed, and die. Nevertheless, they die very slowly and can survive in distilled water for at least 10 days.

In experiment 2, eight battery jars were used. One liter of water and two *Thais* were placed in each. The latter were removed from water of salinity 32.90°/₀₀. The salinity of water in jars 1 to 8 was: distilled, 5.25, 10.05, 12.12, 14.00, 15.96, 19.93 and 32.90°/₀₀, respectively. All jars were aerated by glass and rubber tubing leading off from a small electric air pump.

In jar 8, both animals opened in 40 minutes and remained so throughout the experiment.

In jar 7, one opened in 6 hours and the other in 2 days. The latter animal closed in 8 days and was dead in 11 days. The remaining one closed in 15 days probably because multiplication of bacteria in the water.

In jar 6, one *Thais* opened in 18 hours and the other in three days. They remained attached throughout the experiment although at the end one had the foot partly folded.

Animals in jar 5 opened in 2 and 7 days, respectively, and remained so throughout the experiment.

In jar 4, one specimen opened in 5 days and the other in 9 days. The latter partly folded its foot after 5 days.

In jar 3, both animals opened in 7 days but partly closed two days later and remained that way.

Animals in jar 2 remained closed. One revived in 12 days after being placed in sea water of salinity 27.59°/₀₀. The remaining one was dead by the fifteenth day.

Animals in jar 1 did not open. One revived after 10 days when placed in water of salinity 28.86°/₀₀. The other was dead on the twelfth day.

On the eighth day of the experiment, it was found, due to evaporation and possibly the loss of salts by the animals, that the salinities of the jars had risen. They were in jars 1 to 8, respectively: 1.00 (estimated), 7.21, 11.92, 14.51, 16.42, 18.67, 22.11 and 35.86°/₀₀. They were changed in order to: distilled, 5.26, 10.01, 12.29, 13.99, 16.16, 19.79 and 27.83°/₀₀. This apparently had little effect on the experimental animals for their behaviour was the same after as it was before the change.

The experiment was stopped on December 18. At this time six of the remaining animals in the last five jars were attached. Two had the foot folded but not closed and one was closed tight.

The pH and temperatures were taken 13 times in all. The temperatures changed from 19.8 to 10.0°C and back to 17.1°C. There was no difference between jars greater than 0.5°C at any one time. The pH at the beginning of the experiment ranged from 6.4 in the first jar to 8.0 in the last one. The pH in the lower jars rose so that after the sixth day it fluctuated between 7.6 and 8.4 for all jars.

This experiment shows that *Thais* removed from water of salinity around 33.00°/₀₀ can accustom themselves to water of salinity as low as around 12.00°/₀₀ after several days. It also shows that the time taken for animals to accustom themselves roughly increases directly as the salinity decreases to the lethal or lower toleration point. Animals were not able to tolerate water of a salinity of 10.5°/₀₀ and below, but could live as long as 10 days even in distilled water.

It was found from the above two experiments that the lower salinity toleration point for *Thais* from water of salinity 32.00 to 34.00°/₀₀, was around 10.00 to 11.00°/₀₀. Another experiment was devised to determine this point more exactly. This expectation was not realized, but another discovery of possibly more importance was made, as described below.

The experiment was started on January 28, 1936. Three sets of two battery jars each were used. These each contained 1 liter of aerated water. The salinities from sets 1 to 3, respectively, were: 8.96, 10.03 and 11.06°/₀₀. Two *Thais* were placed in each jar. One animal in set 1 and one in set 2 did not open at all and were dead in 8 and 9 days, respectively. Contrary to what was expected, all ten other animals opened in from 1 hour to 2 days and remained so for 21 days when the experiment was stopped. The average time taken for the animals to open in each pair of jars from 1 to 3, respectively, was 24, 5 and 2 hours. It is seen that time increases as salinity decreases. The temperature and pH of the water was taken 21 times during the 21 days the experiment was run. The water was changed 14 times. The salinity of that used for changes for sets 1 to 3 fluctuated between 9.00 to 9.16, 9.99 to 10.28 and 11.04 to 11.15°/₀₀, respectively. The pH varied from 7.2 to 8.0. The temperature fluctuated between 15.5 and 21.8°C. The greatest difference between jars at any one time was 0.7°C.

Previous to this experiment the animals used had been kept in the running sea water of the laboratory. On January 13, this water dropped below salinity 20.00°/₀₀ for the first time in 3 months. It was at 12.83 and down to 4.38 on January 28. The latter figure was the salinity from which the experimental animals were removed. The evident explanation then for the results obtained is that the *Thais* had somewhat acclimated themselves to lowered salinities in the laboratory, so that their toleration or lethal point of low salinities had fallen still lower. Federighi (1931a) found similar results working on *Urosalpinx cinerea*. He found that these animals from one locality died at a higher salinity than did those from other localities where the average environmental salinities had been lower than in the first locality.

On February 17, the foregoing experiment was stopped and the following one was started. It was really a continuation of the former experiment. All animals from each pair of jars were placed in one jar, making 3, 3 and 4 in jars 1, 2 and 3, respectively. One liter of fresh water of salinity 8.04, 9.04 and 10.04°/₀₀ was placed in jars 1 to 3, respectively. This water was changed using the same salinities on the third and on the fourth days. On the fifth day, the water was changed to salinities of 7.00, 7.85 and 9.04°/₀₀, respectively. On the eighth day, this water was changed. On the ninth and fourteenth day, 100 cc of solution were removed from each jar and 100 cc of tap water added. On the fifteenth day, 150 cc of fresh water were added to each jar.

The temperature of the water during the experiments varied between 12.4 and 24.0°C. The pH varied from 7.4 to 7.9 up to the fifteenth day when the water had turned milky. At this time pH for all three jars averaged 8.3. No water was added thereafter.

All animals remained attached and opened up to the fourteenth day. From that time on the foot was partly folded. One animal in jar 3 was dead on the twenty-third day. Unfortunately, the writer was away from the laboratory at that time and when he returned on the twenty-fifth day the water was foul and the other three animals were dead, proably more from this cause than from the low salinities. Results from this jar had to be disregarded. On the same day, one animal in jar 1 was dead. On the thirtieth day, all animals in jar 1 and two of those in jar 2 were dead. The salinities of these jars were 6.22 and 6.88°/₀₀, respectively. The remaining animal in jar 2 was sensitive to pricking 4 days later when, due to evapoation, the salinity of the water had risen to 7.41°/₀₀. This was lowered to 5.75°/₀₀ and the next day the animal was dead.

This experiment shows that *Thais* can accustom themselves to and live in water of salinities as low as 7.00°/₀₀ if it is lowered slowly, but died when the salinity reaches a point around 6.5°/₀₀.

FIELD EXPERIMENTS

On December 10, 1935, boxes containing *Thais* were placed at six stations. These stations were on Hiles' Shallow Bar near Indian Pass, Picolyne Bar, north end of St. Vincent's

Bar, south end of St. Vincent's Bar, Platform Bar and a small bar in East Bay. Each box was constructed of poultry wire over a wooden frame. Two were put down at each place. One of these contained 8 *Thais* and the other contained 8 *Thais* and 25 adult oysters. These were visited an average of five times each between December 10, 1935 and February 26, 1936.

About January 13, flood waters from rivers above Apalachicola came into the bay and the salinities as a whole took a precipitous drop. Before this date, 10 oysters died from natural causes or were eaten by the *Thais* within the cages. No *Thais* died. From January 13 to February 26, when the salinities were low, 4 oysters died and 36 *Thais* died. Twenty-five of the *Thais* casualties were on the north and south of St. Vincent's Bar and East Bay which were areas of the lowest salinity. Twenty-two of the dead *Thais* were in boxes containing oysters so it cannot be said that they starved to death.

The bottom salinities taken from these stations dropped to a little above 9.0°/oo.

This experiment apparently proves that under natural conditions on the beds, oysters will survive lower salinities than *Thais* so that the range or habitat of oysters is, or may be in part, in areas where the average salinities are lower than *Thais* can tolerate.

This fact was also proven still more conclusively by natural events, for on February 17, 1936, *Thais* on St. Vincent's Bar were seen to be dying. Freshly dead, undecayed animals were taken at this time. From then until February 27 they died in great numbers. On this last date, two apparently moribund animals revived when brought to the laboratory. Since February 27, all *Thais* shells taken on this bar have been empty. Apparently, *Thais* has been exterminated here by fresh water, while most of the oysters lived, although there were some casualties. In March 1936, 41 bushels of material were tonged from 16 bars. *Thais* were taken only on Hiles' Shallow Bar near Indian Pass and it seems that this was the only place where they were present in Apalachicola Bay. Events of that nature seem to happen over and over on the Gulf coast, and result in the killing out of *Thais* and survival of oysters in low-salinity waters following high water or flood periods. They are particularly noticable in Mississippi and Louisiana (Viosca 1928, Gunter 1953).

ENEMIES

The stone crab, *Menippe mercenaria*, can kill and devour *Thais* as noted above (Powell and Gunter 1968). Butler (1954) has stated that hermit crabs kill these conchs and Percy Viosca (personal communication) told the writer that several hermit crabs gathered around *Thais* and pinched their tentacles until they bled to death, after which they pulled the body from the shell and took it for their own.

MISCELLANIA

Gastropod mollusks have existed since the upper Cambrian. As stated previously in this paper, the radula and, by the same token, the odontophore are present in every molluscan class except the Pelecypoda. Even so, as Krutak (1977) has pointed out, the radular teeth of gastropods have not been reported as fossils. This is quite strange insofar as the gastropod mollusks are organisms of vast abundance in the seas. This puzzle is explained if it is assumed that the conodonts, a group with no-known relatives or relations, are really the radular teeth of gastropods and other mollusks, extending back almost to the beginning of animal fossils in the Cambrian age.

REFERENCES CITED

Bayliss, William Maddock. 1927. *Principles of General Physiology*. Longmans, Green, and Co. Ltd. London. 882 pp.

Burkenroad, Martin D. 1931. Notes on the Louisiana conch, *Thais haemastoma* Linn., in its relation to the oyster *Ostrea virginica*. *Ecology* XII(4):656–664.

Butler, Philip A. 1954. The southern oyster drill. 1953 *Proc. Nat. Shelfish. Assoc.* 44:67–75.

Carriker, M. R. 1943. On the structure and function of the proboscis in the common oyster drill, *Urosalpinx cinerea* Say. *J. Morphol.* 73:441–506.

________, Dirk Van Zandt & Garry Charlton. 1967. Gastropod Urosalpinx: pH of accessory boring organ while boring. *Science* 158(3803):920–922.

Clench, William J. 1947. The genera *Purpura* and *Thais* in the Western Atlantic. *Johnsonia* 2(23):61–91.

Cook, H. A. 1895. *The Cambridge Natural History, Molluscs, etc.* Ed., Harmer, S. F. and Shipley, A.E.; Macmillan and Co., New York and London. III:209–243.

Copeland, M. 1918. The olfactory reactions and organs of the marine snails *Alectrion obsoleta* (Say) and *Busycon canaliculatum* (Linn.). *J. Exp. Zoo.* 25:177–277.

Churchill, E. P. 1920. The oyster industry of the Atlantic and Gulf Coast. *U.S. Comm. Fish. Rept.* 1919(1921), Appendix VII, 55 pp.

Dakin, W. J. 1912. Buccinum, the whelk. *Liverpool Marine Biology Committee Memoirs*. London: Williams & Norgate. No. 20, 114 pp.

Danglade, E. 1917. Conditions and extent of the natural Oyster beds and barren bottoms in the vicinity of Apalachicola. *U.S. Comm. Fish. Rept.* (1916), Appendix, pp. 1–78.

Demoran, William & Gordon Gunter. 1956. Ability of *Thais haemastoma* to regenerate its drilling mechanism. *Science* 123(3208):1126.

Dubois, R. 1909. Isomorphisme et isochromatisme symbiotiques chez certains Lamellibranches marins. *Bulletin de l'Institue General de psychologie.* 9e annee, No. 4, 1909.

Federighi, H. H. 1931a. Studies on the oyster drill, *Urosalpinx cinerea* (Say). *Bull. U.S. Bur. Fish.* 47:85–115.

________. 1931b. Salinity death – points of the oyster drill snail *Urosalpinx cinerea* (Say). *Ecology* 12(2):346–353.

Fischer, P. H. 1922. Sur les gastéropodes perceurs. *J. Conchyliol.* 67:1–56.

Fretter, V. 1941. The genital ducts of some British stenoglossan prosobranchs. *J. Mar. Biol. Asso. U.K.* 25:173–211.

Gunter, Gordon. 1936. Radular movements in gastropods. *J. Wash. Acad. Sci.* 26(9):361–365.

_______ . 1952. Radular movement and boring efficiency of gastropods. *Nature* 169:630.

_______ . 1953. The relationship of the Bonnet Carré spillway to oyster beds in Mississippi Sound and the "Louisiana Marsh," with a report on the 1950 opening. *Publ. Inst. Mar. Sci., Univ. Tex.* 3(I):17–71.

_______ & R. W. Menzel. 1957. The crown conch, *Melongena corona*, as a predator upon the Virginia oyster. *Nautilus* 70(3): 84–87.

Herrick, J. C. 1906. Mechanism of the odontophoral apparatus in *Sycotypus canaliculatus*. *Am. Nat.* 40:707–737.

Hibaya, T., E. Iwai & Y. Hashimoto. 1953. Comparative studies on the stomachal plates and crystalline style – II. Structure of the stomachal plates of *Dolabella scapula*. *Bull. Jpn. Soc. Sci. Fish.* 19:1–4.

Huxley, T. H. 1853. On the morphology of the cephalous Mollusca. *Philos. Trans. R. Soc., Lond. B. Biol. Sci.* Pp. 601–638.

Jensen, A. S. 1951a. Do the Naticidae (Gastropoda: Prosobranchia) drill by chemical or by mechanical means? *Vidensk. Medd. Dan. Naturhist. Foren.* 113:251–261.

_______ . 1951b. Do the Naticidae drill by mechanical or by chemical means? *Nature* 167:901.

Johnson, C. W. 1934. List of the marine molluscs of the Atlantic coast from Labrador to Texas. *Proc. Boston Soc. Nat. Hist.* XL(1):118.

Kibbe, I. P. 1898. Oysters and oyster culture in Texas. *Bull. U.S. Fish. Comm.* XVII(1897):313–314.

Krutak, Paul R. 1977. Gastropod radulae: their potential in the fossil record. *Trans. Gulf Coast Assoc. Geol. Soc.* XXVII: 314–322.

Menzel, R. Winston & Sewell H. Hopkins. 1954. Studies on oyster predators in Terrebonne Parish, Louisiana. Texas A&M Research Foundation. Project 9, pp. 1–145.

McGraw, K. A. & G. Gunter. 1972. Observations on killing of the Virginia oyster by the Gulf oyster borer, *Thais haemastoma*, with evidence for a paralytic secretion. *Proc. Nat. Shellfish. Assoc.* 62:95–97.

Moore, Donald R. 1956. Observations of predation on echinoderms by three species of Cassididae. *Nautilus* 69(3):73–76.

Moore, H. F. 1899. Report on the oyster beds of Louisiana. *Rept. U.S. Fish Comm.* 24(1898):49–100.

_______ . 1907. Survey of oyster bottoms in Matagorda Bay, Texas. *Rept. U.S. Fish Comm., Bur. Fish Doc. No.* 610(1905). 86 pp.

_______ & T. B. Pope. 1910. Oyster culture experiments and investigations in Louisiana. *Rept. U.S. Fish Comm., Bur. Fish Doc. No.* 731(1918):1–52.

_______ & E. Danglade. 1915. Conditions and extent of the natural oyster beds and bottoms of Lavaca Bay, Texas. Appendix II. *Rept. U.S. Fish Comm.* 1914:1–45.

Oswald, A. 1894. Der Rüsselapparat der Prosobranchier. *J. Z. Naturwiss.* 28:118–162.

Preyer, W. 1866. Ueber das für Speichel gehaltene Sekret von *Dolium galea. Sitz. Ber. niederrhein. Ges. Natur. Heilkunde in Bonn.* Pp. 6–9.

Powell, Earnest H., Jr. & Gordon Gunter. 1968. Observations on the stone crab in the vicinity of Port Aransas, Texas. *Gulf Res. Rept.* 2(3):285–299.

Ritter, H. P. 1896. Report of a reconnaissance of the oyster beds of Mobile Bay and Mississippi Sound, Alabama. *Bull. U.S. Fish Comm.* XV(1895):325–339.

Schiemenz, P. 1891. Wie bohrt *Natica* die Muscheln an? *Mitt. Zool. Sta. Neapel* 10:153–169.

Swift, F. 1898. The oyster-grounds of the West Florida coast; their extent, condition, and peculiarities. *Bull. U.S. Fish Comm.* XVII(1897):285–287.

St. Amant, Lyle S. 1938. Studies on the biology of the Louisiana oyster drill, *Thais haemastoma haysae.* Master's thesis. Louisiana State University.

Viosca, Percy, Jr. 1928. Flood control in the Mississippi Valley in its relation to Louisiana fisheries. *La. Dep. Conserv. Tech. Pap.* 4:1–16.

Gulf Research Reports

Volume 6 | Issue 3

January 1979

A Study of Four Oyster Reefs in Mississippi

John Ogle
Gulf Coast Research Laboratory

DOI: 10.18785/grr.0603.06

Recommended Citation

Ogle, J. 1979. A Study of Four Oyster Reefs in Mississippi. Gulf Research Reports 6 (3): 261-265.
Retrieved from http://aquila.usm.edu/gcr/vol6/iss3/6

Gulf Research Reports, Vol. 6, No. 3, 261–265, 1979.

A STUDY OF FOUR OYSTER REEFS IN MISSISSIPPI

JOHN OGLE
Oyster Biology Section, Gulf Coast Research Laboratory, Ocean Springs, Mississippi 39564

ABSTRACT A study of four oyster populations in Mississippi over 13 months (May 1978–May 1979) indicates that although oysters are sexually developed during most of the year (10 months), setting was variable in intensity, dependent upon location, and limited in all cases to one or two months. Mortality was variable, dependent upon location and was attributed to high predation at one station and to harvesting and fresh water at the other stations studied. Suggestions for management are discussed.

INTRODUCTION

The oysters and the oyster industry of Mississippi have been the subjects of numerous investigations dating back to the early part of the century. However, data that are available consist of oyster bottom surveys and studies of setting. The densities of oysters on various reefs have been mentioned (Moore 1913, Engle 1948, MacKenzie 1977). An evaluation of different cultch materials (Veal, Brown, and Demoran 1972) conducted during 1971 and 1972 was invalidated by the lack of a spat set. During seven months of 1972, spat setting was monitored on fouling plates at one station in Bay St. Louis, MS (Haburay 1977). Setting was monitored on fouling plates at five stations in Mississippi Sound for one year (October 1976–October 1977) and that same study (McGraw, personal communication) provided information on the growth rates of oysters. However, only one of the five stations was near a commercial reef (Biloxi Bay).

With recent interest in managing, developing and exploiting oysters, this lack of basic information has become apparent. This study was conducted to determine condition, setting, growth and mortality of oysters at four reefs in Mississippi.

MATERIALS AND METHODS

One-cubic-foot samples of reef material were collected monthly for 13 months at four stations: a lagoon at Horn Island, Graveline Bayou, a closed reef in Biloxi Bay, and a tonging reef at Pass Christian. The oysters at Horn Island are harvested publicly for recreation; the reefs at Graveline and Biloxi Bay are dredged for relaying and the reef at Pass Christian is harvested commercially. The Graveline and Pass Christian samples were dredged, while the Horn Island and Biloxi Bay samples were handpicked in shallow water. The number and size of all live oysters were determined and enumerated into four 25-mm-size classes: spat, seed, juvenile, and market sizes (Hofstetter 1977). The number of fresh single valves and boxes was determined and the percent of dead shell material was calculated. The average condition index was calculated according to the procedure of Hopkins (1949) with the shell cavity volume being determined according to the procedure of Galtsoff (1964). Gonadal development was determined on ten oysters by noting the condition of a gonadal smear. Hydrographic data, including temperature determined to the nearest degree Celsius and salinity determined to the nearest ppt with an American Optical total solids refractometer, were recorded for each station monthly.

Manuscript received August 31, 1979; accepted September 28, 1979.

RESULTS

Graveline oysters had the highest condition index (Table 1) throughout most of the study while Horn Island oysters had the lowest condition. Generally, oysters for all four stations had similar seasonal trends. Condition was high during May of both years (1978, 1979). However, values were also high during November 1978 and March 1979 for all stations. Values were low during the summer of 1978 and again during January 1979.

Sexually developed oysters were found during ten months of a yearly period for at least one of the four stations (Table 1). January and February were the only months for which no sexually developed oysters were found at any station. Horn Island oysters were developed the greatest number of months (10 of 13) while oysters from Biloxi Bay and Graveline were developed during 8 of 13 months sampled.

Setting of larvae, based upon spat set on shells, was variable in intensity, dependent upon location and limited to a couple of months. Spat were first noticed during July at Pass Christian with a peak of setting during August. Oysters at Graveline Bayou did not set until November with a peak showing up in the December sample. Setting was most pronounced at Horn Island with a peak during August. An additional set occurred during November at that station. A very low set occurred during August at Biloxi Bay.

Growth of size classes was difficult to follow at Biloxi Bay due to the insignificant set, and at Graveline due to the late set in 1978. Growth of oysters at Horn Island was faster than growth at Pass Christian. Oysters which set during August at Horn Island were seed size in 5 months and had started to show up in the juvenile size class in 9 months (Table 2). Oysters which set during July at Pass Christian were seed size in 6 months and were showing up in the

TABLE 1.

Average condition index and percent sexually developed oysters based upon ten oysters from four reefs in Mississippi over a 13-month period.

Station	1978								1979				
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
						Condition Index							
Biloxi Bay	7.83	6.40	4.55	5.68	5.31	6.04	8.53	7.74	4.72	7.65	11.80	9.10	13.34
Graveline	7.46	7.19	5.68	4.68	6.28	10.01	16.80	13.54	11.19	13.09	16.80	10.60	11.69
Pass Christian	8.24	4.74	4.56	5.59	5.22	5.51	12.13	8.08	11.00	9.43	17.00	10.00	9.78
Horn Island	6.60	6.63	4.56	3.97	6.09	4.04	7.21	7.78	7.78	7.19	8.80	8.34	6.09
						Percent Sexually Developed Oysters							
Biloxi Bay	90	100	100	90	70	10	0	0	0	0	0	70	80
Graveline	30	100	80	100	80	40	0	0	0	0	0	10	88
Pass Christian	80	100	50	80	70	50	20	40	0	0	0	90	100
Horn Island	40	50	90	100	100	20	0	20	0	0	0	90	90

TABLE 2.

Size frequency distribution of live oysters contained in a standard (1 cubic foot) dredge sample.

Percent Size Distribution	1978								1979				
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
						Biloxi Bay							
Spat (0–25 mm)	1.9	2.0	1.7	7.0	1.0	2.9	3.6	6.0	1.8	1.2	2.1	1.7	4.8
Seed (26–50 mm)	63.4	23.0	33.5	18.5	16.0	15.1	16.5	24.0	17.2	12.5	45.7	21.1	20.8
Juvenile (51–75 mm)	23.8	35.0	39.1	57.3	44.3	52.7	44.4	32.0	38.4	43.4	44.3	38.6	48.8
Market (75 mm)	12.9	40.0	25.7	17.2	38.7	29.3	35.5	38.0	42.6	42.9	7.9	38.6	25.6
						Graveline Bayou							
Spat (0–25 mm)	1.4	0.8	1.2	8.2	8.3	1.1	56.3	64.8	49.8	53.9	59.9	55.0	56.9
Seed (26–50 mm)	21.3	13.3	25.9	17.0	19.0	46.3	14.7	9.3	14.8	10.4	10.1	11.3	14.1
Juvenile (51–75 mm)	28.1	40.7	31.3	32.7	31.0	37.9	11.3	14.6	15.5	11.4	11.9	14.1	14.0
Market (75 mm)	49.2	45.2	41.1	42.1	41.7	14.7	17.7	11.3	19.9	24.3	18.1	19.6	15.0
						Pass Christian							
Spat (0–25 mm)	6.4	1.9	41.5	51.8	40.9	26.2	19.4	15.3	14.3	10.7	12.9	13.5	7.7
Seed (26–50 mm)	28.2	23.5	11.8	9.4	19.8	5.0	9.2	13.3	73.2	16.6	29.5	18.9	27.8
Juvenile (51–75 mm)	30.9	26.1	17.8	17.6	26.6	18.8	10.2	16.3	7.2	19.8	37.6	15.3	28.9
Market (75 mm)	34.5	48.5	28.9	21.2	12.7	50.0	61.2	55.1	5.3	52.9	20.0	52.3	35.6
						Horn Island Lagoon							
Spat (0–25 mm)	34.9	12.9	19.1	73.0	46.7	56.0	63.1	35.2	52.5	56.0	50.2	51.5	29.5
Seed (26–50 mm)	48.3	73.9	62.7	25.0	29.0	19.0	20.6	31.8	39.4	32.2	46.1	22.7	40.8
Juvenile (51–75 mm)	13.6	10.8	17.1	2.0	18.3	7.0	13.9	26.5	7.6	11.0	3.5	17.7	22.1
Market (75 mm)	3.2	2.4	1.2	0.0	6.0	17.7	2.4	6.5	0.5	0.8	0.2	8.1	7.6

juvenile size class in 10 months. The November set of oysters at Horn Island had reached seed size in 4 months.

Horn Island contained the fewest marketable oysters, while Pass Christian had the most market-size oysters (Table 2). The greatest number of marketable oysters was typically found during the fall months. Graveline Bayou was depleted of marketable oysters during October due to dredging.

The amount of dead shell was high for Pass Christian, but the most dead shell occurred at Graveline after it was dredged. Horn Island contained almost no dead shell material (Table 3).

Monthly mortality was high for Horn Island and Pass Christian (Table 4). Horn Island oysters experienced high mortality during June, July, August, January, March and April. Pass Christian oysters experienced high mortality during October, November, December and January, and again during March, April and May. Graveline oysters experienced a high mortality during October, while the highest mortality for Biloxi Bay oysters was during August.

The highest temperature (34°C) was recorded for Biloxi Bay whereas the lowest temperature (6°C) was recorded for the lagoon at Horn Island (Table 5). The highest recorded salinity (32 ppt) was for Horn Island while fresh water occurred at Graveline and Pass Christian. The lowest salinity recorded for Biloxi Bay was 4 ppt and the lowest salinity recorded for Horn Island was 10 ppt.

DISCUSSION

The oyster population at Horn Island should be considered marginally harvestable. Reproductive potential was greatest at that station with two sets of spat occurring during the year, but there was not much cultch for the spat to set on. That resulted in the elongated shells and large clusters of oysters characteristic for areas of soft, muddy bottoms. Oyster growth in the lagoon was rapid but there were few market-size oysters, indicating a high natural predation and mortality. Oyster drills were probably the major cause of mortality. The protozoan parasite *Perkinsus marina*, responsible for oyster mortalities in areas of high salinity, especially during warm months of the year, was not prevalent during this study (Ogle, unpublished manuscript). The lagoons of Horn Island could be evaluated as spat-collecting areas utilizing artificial spat collectors.

The oysters at Graveline were generally the best oysters in Mississippi during this study period. The great number of large-sized oysters and their good condition was offset only by their being in an area closed to harvesting. The area was last harvested during February 1974 (W. J. Demoran, personal communication). Harvesting of the bayou during October of this study period for relaying of the oysters afforded the author the opportunity to investigate the effects of dredging on a reef and the effect of relaying oysters to new beds (Ogle 1979). Dredging of the bayou reduced the number of adult oysters and increased the percentage of dead shell, as would be expected. The highest monthly mortality was also recorded during the month that dredging occurred. These effects were offset by an excellent set of spat the month following dredging. Graveline Bayou, being protected from adverse weather and accessible to small craft, would make an excellent tonging reef. Consideration should be given to eliminating the sources of pollution into the bayou. This area would then serve eastern Mississippi, which presently has no commercial open oyster reefs.

Biloxi Bay, another closed oyster area, was dredged for relaying oysters during September and October. Dredging occurred adjacent to the sampling station, so effects of dredging were not recorded in this study. Biloxi Bay has been heavily dredged during the past several years. There was no significant spat set during this study and growth is known to be slow in this area, requiring 2 to 2½ years to produce market-size oysters (Ogle, unpublished data). The oyster bottom should be resurveyed to insure that it is not being overharvested and restrictions placed on the taking of oysters from this area.

Pass Christian was the only commercially harvested reef in this study. Harvesting occurred from September until April with heaviest tonging during October, November, December and January—months for which mortalities were also high. Interestingly, these were also months with the highest percent of marketable oysters. Mortalities during March, April and May were attributed to low-salinity waters from the flooding of the Pearl River and the opening of the Bonnet Carré Spillway on April 16, 1979. Should fresh water persist and mortality increase, planting of seed oysters may be required.

This study should be considered preliminary due to its limited scope and duration. In order to study the dynamics of a population adequately, especially oysters which require 2 years to reach a marketable size, several year classes should be followed over a period of several years. In addition, only four reefs were studied. Sampling should be expanded to cover all the major reefs in Mississippi. Because of the nonrandom nature of oysters on bottoms, the use of a standard volume sample only provided an indication of population dynamics. These data can then be used with surveys of the extent of oyster bottoms to estimate total oyster populations. The last survey of oyster reefs in Mississippi was completed in 1977 and should continue to be updated periodically.

ACKNOWLEDGMENTS

I would like to thank Mr. John Supan, who collected most of the samples in this study, and Ms. Kathy Flurry who worked up those samples.